LASIGE
Large-Scale Informatics Systems Laboratory

TClouds

Software Security in the Clouds

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2nd Ibero-American Web Applications Security Conference
IBWAS'10

Outline of the talk

- Motivation
- Security challenges in the cloud
- Software security in the cloud
- Further security: distributing trust
- Conclusions

Cloud computing

- Fundamental ideas
  - Computing as a utility
  - Pay-as-you-go (public cloud)
  - Resource pooling
  - Elasticity
- Implementation
  - Large-scale datacenters
  - Cloud provider vs cloud users

Cloud computing

Service models:

- *Infrastructure as a Service* (IaaS): virtual machines, storage (e.g., Amazon EC2, Windows Azure)
- *Platform as a Service* (PaaS): programming and execution (e.g., Google AppEngine, Force.com)
- *Software as a Service* (SaaS): mostly web applications (e.g., Yahoo! Mail, Google Docs)
- Web is crucial in PaaS and SaaS – role of OWASP?

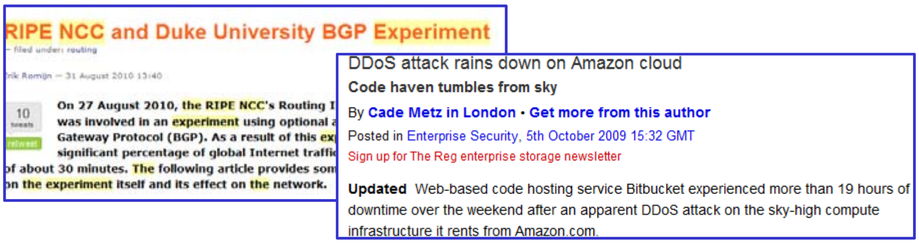
Security in the cloud?

- Recall the three attributes
  - Confidentiality – no disclosure of data to unauthorized entities
  - Integrity – no unauthorized modifications of the system or data
  - Availability – readiness of the system to provide its service
- The three are important in the cloud
- Challenges
  - The system is no longer in the organization premises
  - The system is shared with other users
  - The access is through the internet

SECURITY CHALLENGES IN THE CLOUD

Unavailability

- Problems in the Internet – relatively frequent
  - Congestion
  - Problems in the client or ISP equipment (routers, etc.)
  - More global problems (Cisco bug + RIPE NCC test Aug. 2010)
- Problems at the cloud (e.g., Google AppEngine)
- Denial of service attacks (e.g., Amazon 2009)



RIPE NCC and Duke University BGP Experiment

– filed under: routing

rik Romijn — 31 August 2010 13:40

10 tweets

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On 27 August 2010, the RIPE NCC's Routing I
was involved in an experiment using optional a
Gateway Protocol (BGP). As a result of this ex
significant percentage of global Internet traffic
of about 30 minutes. The following article provides som
on the experiment itself and its effect on the network.

DDoS attack rains down on Amazon cloud

Code haven tumbles from sky

By **Cade Metz in London** • **Get more from this author**

Posted in Enterprise Security, 5th October 2009 15:32 GMT

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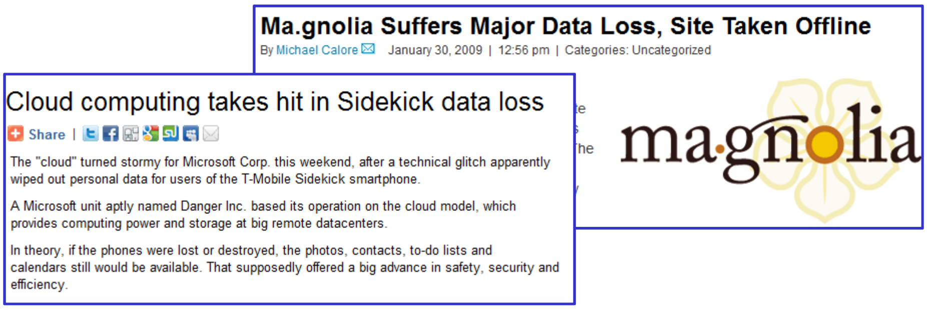
Updated Web-based code hosting service Bitbucket experienced more than 19 hours of downtime over the weekend after an apparent DDoS attack on the sky-high compute infrastructure it rents from Amazon.com.

Loss and corruption of data

Can happen in the cloud as anywhere else

- Danger Inc. / Sideckick lost contacts, notes, photos etc. of its clients; took days to recover them (Oct. 2009)
- Ma.gnolia lost all data from all clients, half TB (Feb.2009)



Ma.gnolia Suffers Major Data Loss, Site Taken Offline

By Michael Calore ✉ January 30, 2009 | 12:56 pm | Categories: Uncategorized

Cloud computing takes hit in Sidekick data loss

Share |

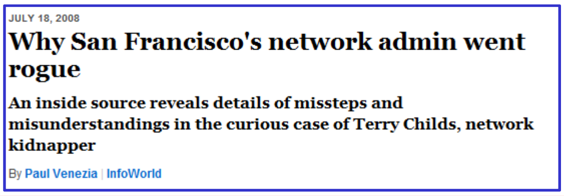
The "cloud" turned stormy for Microsoft Corp. this weekend, after a technical glitch apparently wiped out personal data for users of the T-Mobile Sidekick smartphone.

A Microsoft unit aptly named Danger Inc. based its operation on the cloud model, which provides computing power and storage at big remote datacenters.

In theory, if the phones were lost or destroyed, the photos, contacts, to-do lists and calendars still would be available. That supposedly offered a big advance in safety, security and efficiency.

Privacy/confidentiality violation

- Data is in the cloud provider machines
  - The provider may be trusted; there are legal defenses; but
- There can be a malicious insider
  - Can capture passwords, private keys, software, etc.
  - Not specific in the cloud, but the cloud operators are unknown/…
- Demo of operator/sysadmin capturing private keys
  - Basic cloud environment emulation: Xen hypervisor
  - Dom-0, Dom-1
  - Video
  - Only 2 commands needed!



JULY 18, 2008

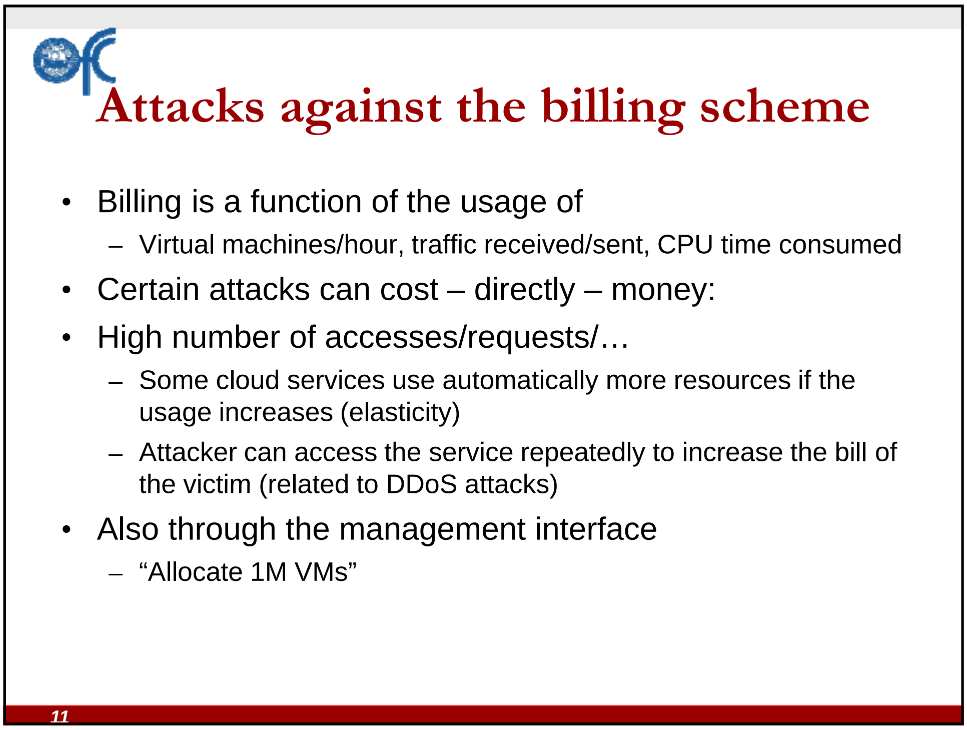
Why San Francisco's network admin went rogue

An inside source reveals details of missteps and misunderstandings in the curious case of Terry Childs, network kidnapper

By Paul Venezia | InfoWorld

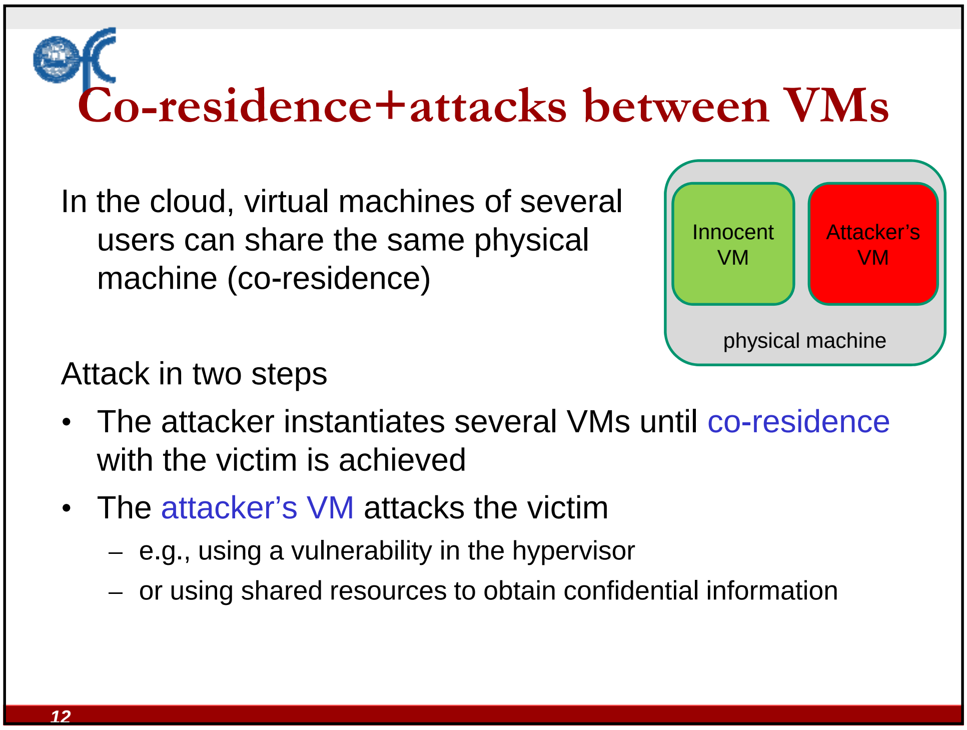
Attacks via management interface

- In the cloud the attack surface is expanded with the *cloud management interface*
  - Control/monitoring of virtual machines, users, etc.
  - Web console, web services, REST
- Attacks through the interface
  - Vulnerabilities that allow personification of legitimate user: SQLI, XMLI, XSS, CSRF, etc.
  - Microsoft, “Secure Use of Cloud Storage”, July 2010
- Phishing to obtain authentication credentials
  - And other attacks involving social engineering



Attacks against the billing scheme

- Billing is a function of the usage of
  - Virtual machines/hour, traffic received/sent, CPU time consumed
- Certain attacks can cost – directly – money:
- High number of accesses/requests/…
  - Some cloud services use automatically more resources if the usage increases (elasticity)
  - Attacker can access the service repeatedly to increase the bill of the victim (related to DDoS attacks)
- Also through the management interface
  - "Allocate 1M VMs"



Co-residence+attacks between VMs

In the cloud, virtual machines of several users can share the same physical machine (co-residence)

Innocent VM
Attacker's VM
physical machine

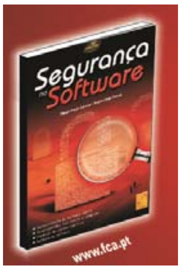
Attack in two steps

- The attacker instantiates several VMs until co-residence with the victim is achieved
- The attacker's VM attacks the victim
  - e.g., using a vulnerability in the hypervisor
  - or using shared resources to obtain confidential information

SOFTWARE SECURITY IN THE CLOUD

Software

- Software is a key security problem in the cloud
  - Attacks via management interface are possible due to vulnerabilities
  - Attacks between VMs are also possible due to vulnerabilities
  - And, of course, attacks against the users' applications (not specific in the cloud)
- A list of solutions for software security



Solution 1 – Secure programming

- Aka “do the right thing”
- Many vulnerabilities are left by programming mistakes

- Buffer overflows
  – Simply check if there is enough space in the destination buffer
- SQL injection
  – Sanitize the inputs
- Cross Site Scripting
  – Sanitize the inputs, encode the outputs

- but to err is human and code can be huge…

Solution 2 – Runtime protection

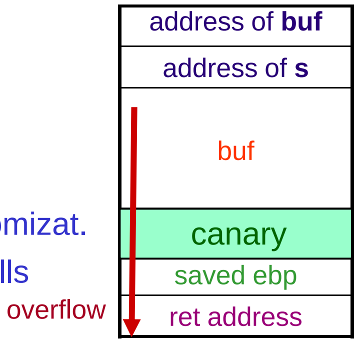
A low level example: Canaries / Stack cookies

- Compiler introduces canaries and checks

```
void test(char *s) {
  push canary;
  char buf[10];
  strcpy(buf, s);
  …
  if (canary is changed) {log; exit;};
}
```

Another: Address space layout randomizat.

Higher level example: webapp firewalls



Solution 3 – Static code analysis

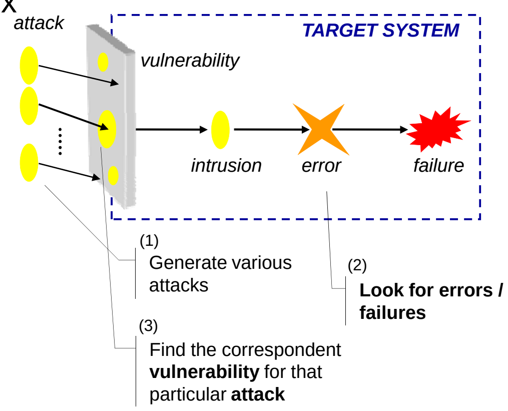
- Vulnerabilities are in the source code so a solution is… to search for them
  - But it's like finding a needle in the haystack
- Code analyzers do it automatically
  - "read" the (source) code and check if certain rules are satisfied (e.g., is memory free'd twice?)
- Commercial tools are available
  - Fortify (now HP), Coverity, Ounce Labs (now IBM)

Solution 3 – Static code analysis

- Code analyzers work essentially in two phases
  - Generate an Abstract Syntax Tree – AST (like a compiler)
  - Search for vulnerabilities in the AST; several ways:
- Syntactic analysis – check if "dangerous" functions are called (e.g., *gets* almost always vulnerable)
- Type checking – check if data is manipulated according to its type (e.g., *unsigned int* = *int* is problematic)
- Control-flow analysis – follow the control flow paths and do several checks (e.g., if there are double frees)
- Taint checking – follow the data flow and check if input reaches dangerous functions (e.g., *strcpy*)

Solution 4 – Attack injection/fuzzing

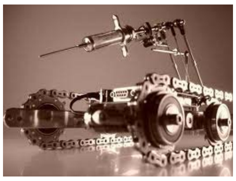
- Look for vulnerabilities without delving into the complexity of the software, i.e., looking at it as a black box



(1) Generate various attacks

(2) **Look for errors / failures**

(3) Find the correspondent **vulnerability** for that particular **attack**



Solution 4 – Attack injection/fuzzing

- Fuzzers
  - Late 80s/early 90s Miller/Fredrikse/So were studding the integrity of Unix command line utilities
  - During a thunderstorm one was attempting to use the utilities over a dial-up connection but the utilities were crashing
  - Data was being modified in the line due to noise
  - Thus they developed an utility called *fuzz* to generate random input and test the robustness of software

- Currently used to find vulnerabilities in software
  - Very successfully…

Solution 4 – Attack injection/fuzzing

- Recursive fuzzing
  - Iterating though all possible combinations of characters from an alphabet
  - Ex.: URL followed by 8 hexadecimal digits; try all possible combinations of the 8 digits
- Replacive fuzzing
  - Iterating though a set of predefined values, called <u>fuzz vectors</u>
  - Ex.: look for XSS vulnerabilities by providing the following inputs:
    - >"><script>alert("XSS")</script>&
    - ";!--"<XSS>=&{()}
- Attack injection (AJECT project)
  - Pick a state for the target and an input to inject; put the target in that state; inject; monitor; repeat

Other solutions

- Security-aware software development processes
- Software auditing
- Testing
- Validation and encoding
- Programming language security
- Virtualization
- Trusted computing

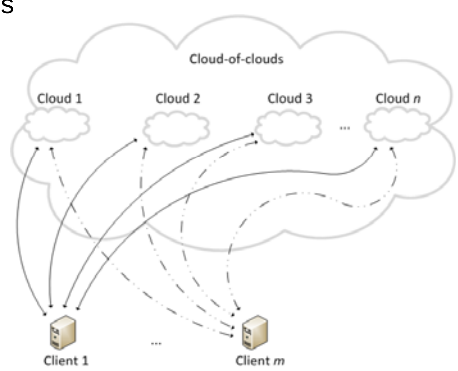
FURTHER SECURITY: DISTRIBUTING TRUST

Security beyond software

- Some problems do not come from software (mostly)
  - Unavailability
  - Loss and corruption of data
  - Privacy/confidentiality violation – malicious insider
  - Vendor lock-in (not security)
- The malicious operator/sysadmin is particularly difficult
- Solution: distributed trust
  - Use several clouds – cloud-of-clouds
  - Each cloud has a (disjoint) set of operators
  - Assumption: there are no coalitions among clouds/operators

Example Clouds-of-clouds: DepSky

- Storage cloud formed by several storage clouds
  - Windows Azure, Amazon S3, Rackspace, Nirvanix
- Data is stored in all clouds – running a quorum algorithm
  - Any operation involves 2 steps
  - Write: 1st write metadata, 2nd write data
- Basic mechanisms
  - Data is encrypted
  - Keys are available because stored in the clouds using *secret sharing*
  - Cost is 2x one cloud by using erasure codes



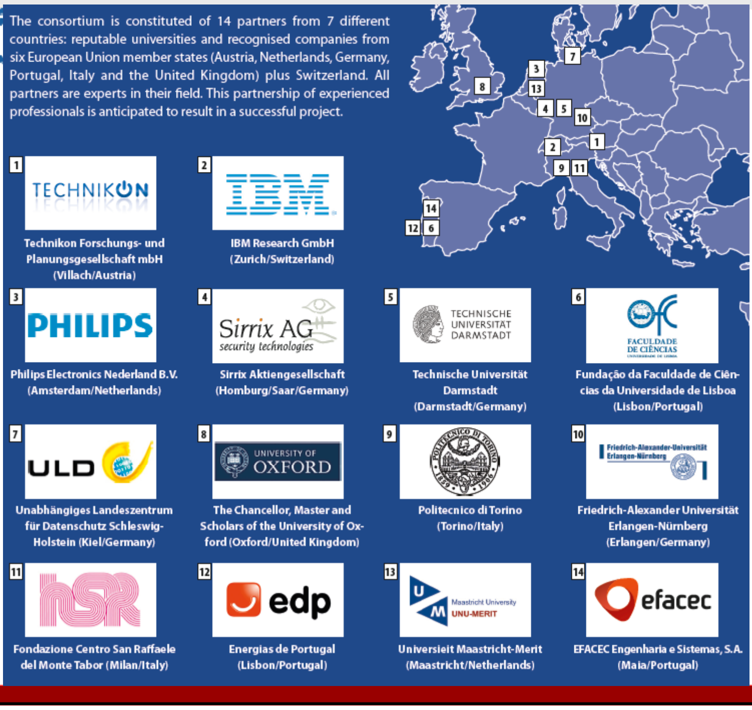
DepSky (cont.)

- Properties
  - Availability: data is available even if one cloud is not
  - Integrity: data is not lost/corrupted even if there is a cloud failure
  - Privacy/confidentiality: data is encrypted
  - Vendor lock-in: the cost of exchanging one of the clouds is a fraction of what it might be
- Challenge: computing cloud-of-clouds
  - Data can't be computed while encrypted
  - IaaS, running VMs

Tclouds - Trustworthy Clouds

Privacy and Resilience for Internet-scale Critical Infrastructure

- European Community project, Framework 7 (7.5 MEuro)
- Start: 1 Oct. 2010; 3 years
- Mission:
  - *To develop an advanced cloud infrastructure that can deliver computing and storage that achieves a new level of security, privacy, and resilience yet is cost-efficient, simple, and scalable*
  - *To change the perceptions of cloud computing by demonstrating the prototype infrastructure in socially significant application areas: energy and healthcare*



The consortium is constituted of 14 partners from 7 different countries: reputable universities and recognised companies from six European Union member states (Austria, Netherlands, Germany, Portugal, Italy and the United Kingdom) plus Switzerland. All partners are experts in their field. This partnership of experienced professionals is anticipated to result in a successful project.

1 Technikon Forschungs- und Planungsgesellschaft mbH (Villach/Austria)

2 IBM Research GmbH (Zurich/Switzerland)

3 Philips Electronics Nederland B.V. (Amsterdam/Netherlands)

4 Sirrix Aktiengesellschaft (Homburg/Saar/Germany)

5 Technische Universität Darmstadt (Darmstadt/Germany)

6 Fundação da Faculdade de Ciências da Universidade de Lisboa (Lisbon/Portugal)

7 Unabhängiges Landeszentrum für Datenschutz Schleswig-Holstein (Kiel/Germany)

8 The Chancellor, Master and Scholars of the University of Oxford (Oxford/United Kingdom)

9 Politecnico di Torino (Torino/Italy)

10 Friedrich-Alexander Universität Erlangen-Nürnberg (Erlangen/Germany)

11 Fondazione Centro San Raffaele del Monte Tabor (Milan/Italy)

12 Energias de Portugal (Lisbon/Portugal)

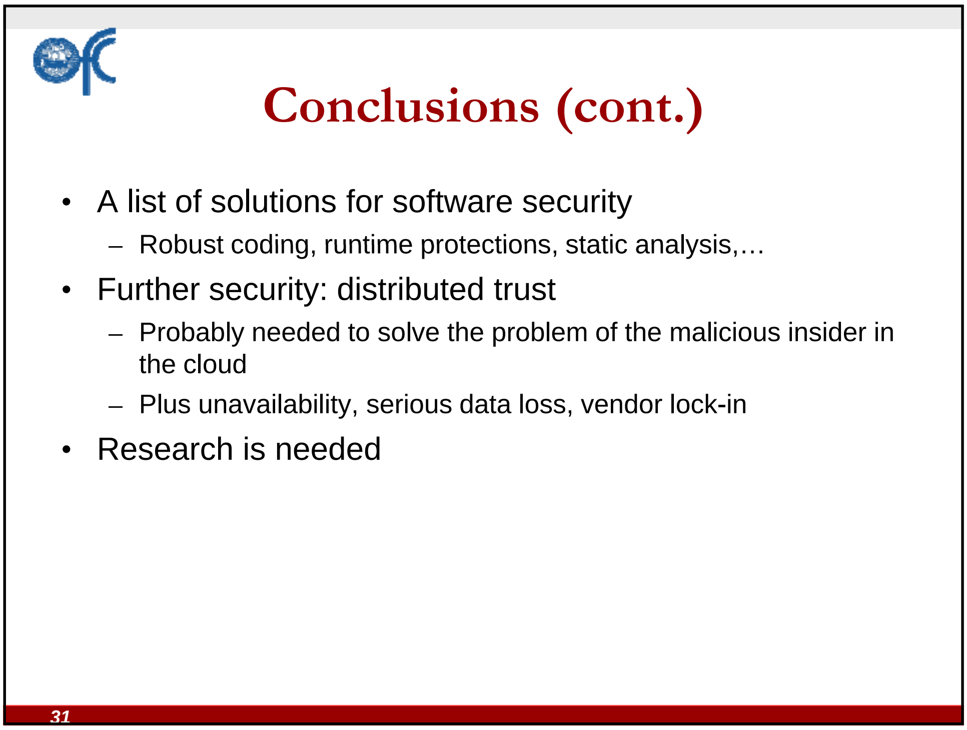
13 Universieit Maastricht-Merit (Maastricht/Netherlands)

14 EFACEC Engenharia e Sistemas, S.A. (Maia/Portugal)

CONCLUSIONS

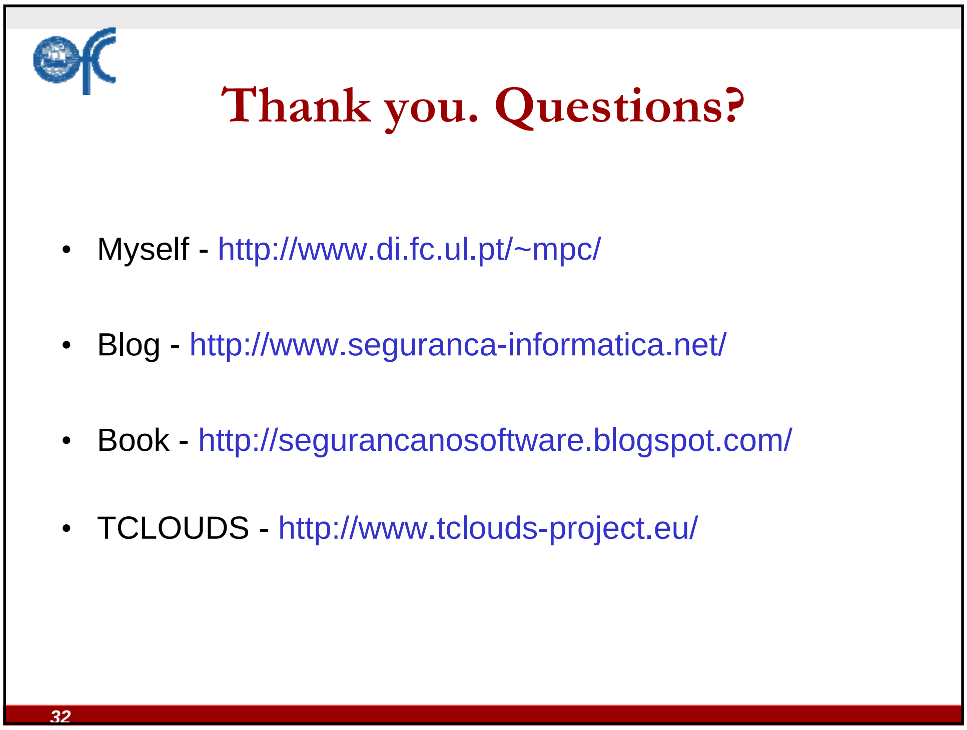
Conclusions

- Not an attempt to present global solutions for cloud sec.
  - Presented the main problems from the user point of view
- “Cloud computing is about gracefully *losing control while maintaining accountability*”
  - CSA Security Guidance for Critical Areas of Focus in Cloud Computing V2.1, Dec. 2009
- Care with contract, analyze, monitor, security controls
- Some companies (small, medium) are probably much better with the cloud
- For others the insecurity is unacceptable



Conclusions (cont.)

- A list of solutions for software security
  - Robust coding, runtime protections, static analysis,…
- Further security: distributed trust
  - Probably needed to solve the problem of the malicious insider in the cloud
  - Plus unavailability, serious data loss, vendor lock-in
- Research is needed



Thank you. Questions?

- Myself - http://www.di.fc.ul.pt/~mpc/
- Blog - http://www.seguranca-informatica.net/
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